AF/1725

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
Before the Board of Patent Appeals and Interferences

In re Patent Application of Atty Dkt. 839-820
C# M#

WANG Group Art Unit: 1725

Serial No. 09/735,503 Examiner: L. Tran

Filed: December 14, 2000 Date: May 22, 2003

Title: METHOD USING SECONDARY ORIENTATION TO TUNE BUCKET NATURAL FREQUENCY

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

☐ **Correspondence Address Indication Form Attached.**

☐ **NOTICE OF APPEAL**
Applicant hereby appeals to the Board of Appeals from the decision dated _____ of the Examiner twice/finally rejecting claims _____ ($ 320.00) $

☒ An appeal **BRIEF** is attached in triplicate in the pending appeal of the above-identified application ($ 320.00) $ 320.00

☐ Credit for fees paid in prior appeal without decision on merits -$ ( )

☐ A reply brief is attached in triplicate under Rule 193(b) **(no fee)**

☐ Petition is hereby made to extend the current due date so as to cover the filing date of this paper and attachment(s) **($110.00/1 month**; $410.00/2 months; **$930.00/3 months**; $1450.00/4 months) $

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☐ Applicant claims "Small entity" status, enter ½ of subtotal and subtract -$( )
☐ "Small entity" statement attached.

SUBTOTAL $ 320.00

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TOTAL FEE ENCLOSED $ 320.00

Any future submission requiring an extension of time is hereby stated to include a petition for such time extension. The Commissioner is hereby authorized to charge any deficiency, or credit any overpayment, in the fee(s) filed, or asserted to be filed, or which should have been filed herewith (or with any paper hereafter filed in this application by this firm) to our **Account No. 14-1140.** A duplicate copy of this sheet is attached.

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#17 5/27/03

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
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In re Patent Application of

WANG — Atty. Ref.: 839-820

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For: METHOD USING SECONDARY ORIENTATION TO TUNE BUCKET NATURAL FREQUENCY

* *

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APPEAL BRIEF

Sir:

Applicant hereby appeals the Final Rejection of January 24, 2003, Paper No. 14.

REAL PARTY IN INTEREST

The real party in interest is General Electric Company, a corporation of the state of New York.

RELATED APPEALS AND INTERFERENCES

Appellant, the undersigned, and the assignee are not aware of any related appeals or interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

STATUS OF CLAIMS

Claims 1-4 and 6-8 are pending and have been rejected. No claims have been substantively allowed.

STATUS OF AMENDMENTS

No amendments have been filed since the date of the Final Rejection.

SUMMARY OF INVENTION

The invention relates to gas turbine bucket construction and, more particularly, to using secondary orientation to tune turbine bucket natural frequencies. With reference to Figure 1, in a single crystal alloy, the material directions along the X' and Y' axes are termed secondary orientation, while that along the Z' direction is termed as the primary orientation. The secondary orientation is defined by the angle θ_s between the engine axial direction X and the material direction X', which is the same as the angle between the engine tangential direction Y and the material direction Y'.

Operating frequencies of turbine buckets can be determined in the design phase using engineering models and the like as would be apparent to those of ordinary skill in the art. With reference to Figures 2 and 3, the data therein is based on known Finite Element (FE) Analyses and is validated through engine tests. Similar engineering models by FE analyses can be used to determine bucket natural frequencies. It is important to avoid resonance by a sufficient margin to improve operating efficiency, and it thus may be necessary to "tune" the natural frequencies of a turbine bucket. See, for example, page 3, lines 2-15.

In a bucket of single crystal alloy, the shear modulus that determines the torsional frequencies is dependent on the secondary orientation θ_s. The tensile modulus along the radial direction that determines the flexure frequencies, on the other hand, is insensitive to the secondary orientation. Thus, with the method of the invention, the secondary

orientation can be used to tune the torsional frequencies without affecting the flexure frequencies. Exemplary Figure 2 shows the change of 1T and 2T frequencies as a function of the secondary orientation. Figure 3 shows the change of 1-2S and 1-3S frequencies as a function of the secondary orientation. It is known that changes in the secondary orientation will not affect the flexure frequencies (such as 1F, 2F, etc.). Moreover, the change in secondary orientation does not entail changes in turbine bucket weight and shape. To implement certain preferred secondary orientation in an investment casting process is a relatively easy operation, thus the impact is minimal on manufacturing cost. See, for example, page 3, line 16 – page 4, line 2.

The data for Figures 2 and 3 is derived from FE analyses, where first analyses are conducted by incorporating the secondary orientation in the engineering model, then the results are correlated with the engine test results. Subsequently, the secondary orientation is varied, and the curves are completed. In the investment casting process, the secondary orientation is controlled by placing the crystal seed along a desired direction. Placing of the crystal seed in the investment casting process does not affect the physical features of the turbine bucket, such as the bucket weight or shape, and does not entail any additional manufacturing operation or cost. As shown in Figures 2 and 3, the desired direction of the crystal seed or secondary orientation is selected to effect a desired percentage change in turbine bucket natural frequencies. See, for example, page 4, lines 3-19.

ISSUES

Whether claims 1-4 and 6-8 are unpatentable under 35 U.S.C. §102(b) over U.S. Patent No. 4,605,452 to Gemma et al.

GROUPING OF CLAIMS

Claims 2-4 stand or fall together with claim 1, and claims 7 and 8 stand or fall together with claim 6.

ARGUMENT

Claims 1-4 and 6-8 are not unpatentable under 35 U.S.C. §102(b) over U.S. Patent No. 4,605,452 to Gemma et al.

It is settled that anticipation under 35 U.S.C. §102(b) requires the disclosure in a single prior art reference of each element of the claim under consideration. See, e.g., *W.L. Gore & Assocs. v. Garlock, Inc.*, 220 USPQ 303, 313 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984).

Independent claim 1 defines a step of tuning a natural frequency of the turbine bucket without modifying physical features of the turbine bucket, wherein this step is practiced by, prior to investment casting the turbine bucket with a single crystal alloy, placing a crystal seed along a desired direction according to an orientation including all angles between 0-90° relative to an engine axial direction to thereby effect a desired percentage change in the natural frequency of the turbine bucket. In this context, the Office Action recognizes that Gemma is silent with respect to tuning the "natural frequency" of a turbine bucket. The Office Action contends, however, that "it is inherent that every time when Gemma et al. arrange the crystal seed to a different orientation, at any angle, the natural frequency has been tuned to a different value." As described in the present specification, any change in secondary orientation of the crystal seed indeed has an affect on the bucket natural frequency. Claim 1 of the present invention, however, specifies that the crystal seed is placed along a desired direction to thereby effect a

desired percentage change in the natural frequency of the turbine bucket. Since Gemma merely orients a single crystal to provide better fatigue resistance, Gemma at least lacks even a remote teaching of placing the crystal seed along a desired direction to effect a desired natural frequency percentage change.

In addition, at the Examiner's suggestion during an interview conducted on July 16, 2002, claim 1 was amended to specify that the crystal seed can be placed along the desired direction according to an orientation including all angles between 0-90° relative to an engine axial direction. The Office Action contends that the single crystal in Gemma is placed in an orientation including all angles from 0-90°, referring to column 13, lines 1-6. A closer reading of the Gemma patent, however, indicates that all angles between 0-90° were tested in Gemma with acceptable results only between about –10° to +20°. As recognized by the Examiner during the interview, Gemma thus in fact teaches away from other orientation angles since such angles would effect results contrary to those specifically intended.

Independent claim 6 defines related subject matter, including the steps of (a) placing a crystal seed along a desired orientation including all angles between 0-90° relative to an engine axial direction; and (b) investment casting the turbine bucket with a single crystal alloy, wherein the desired orientation is selected to tune torsional frequencies without affecting flexure frequencies and to effect a desired percentage change in the turbine bucket natural frequency. As discussed above, Gemma lacks the step of placing a crystal seed along a desired orientation including all angles between 0-90°. Additionally, Gemma lacks a step of selecting a desired orientation to tune torsional

frequencies to effect a desired percentage change in the natural frequency of the turbine bucket.

Moreover, it is important to note that fatigue and frequencies are two distinct behavior and phenomenon and are governed by different physical processes and mathematical descriptions. For example, fatigue is dependent on stresses and local temperatures and thus a local or point property. In a structure, if at a particular point the stress and temperature is high so that the fatigue life is low, the structure will fail due to the failure of that point, regardless of the status at other points. Frequencies, on the other hand, are global properties. The frequencies of a particular structure depend on the stiffness distribution in the structure. The change of stiffness at a local point does not have a significant impact on the frequency of the structure. Indeed, the approaches to solve problems in these two subjects are distinctly different.

As would be apparent to those of ordinary skill in the art, a method to optimize fatigue is incompatible with optimization of frequency. Actually, in the Gemma patent, the method to optimize fatigue is to set the secondary orientation such that the orientation is tangent to the blade surface in the critical crack prone regions just behind the leading edge of the air foil at about 40-80% of the air foil span. As noted, according to the Gemma patent, "a representative improved gas turbine blade will have a secondary orientation angle of -10 to +20 degrees . . .." See the Abstract. Thus, Gemma's method produces an optimal secondary angle of -10 to 20 degrees, while as noted above, the method according to the present invention could produce a secondary angle of any value (based on the current margin and Fig. 2 and Fig. 3 and method of tuning).

Still further, Gemma's invention is not to control the secondary orientation but to use the secondary orientation to reach a certain objective (to optimize fatigue in particular). Optimizing frequencies, however, cannot be derived from optimized fatigue. The two methods are independent and distinctively different from each other as discussed above.

With respect to the dependent claims, Appellant respectfully submits that these claims are allowable at least by virtue of their dependency on an allowable independent claim.

Appellant thus respectfully submits that the rejection is misplaced.

CONCLUSION

In conclusion it is believed that the application is in clear condition for allowance; therefore, early reversal of the Final Rejection and passage of the subject application to issue are earnestly solicited.

Respectfully submitted,

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APPENDIX

CLAIMS ON APPEAL

1. A method of manufacturing a turbine bucket comprising:

(a) investment casting the turbine bucket with a single crystal alloy; and

(b) tuning a natural frequency of the turbine bucket without modifying physical features of the turbine bucket, wherein step (b) is practiced by, prior to step (a), placing a crystal seed along a desired direction according to an orientation including all angles between 0°-90° relative to an engine axial direction to thereby effect a desired percentage change in the natural frequency of the turbine bucket.

2. A method according to claim 1, wherein step (b) is practiced by tuning the natural frequency of the turbine bucket without affecting turbine bucket weight.

3. A method according to claim 1, wherein step (b) is practiced by tuning the natural frequency of the turbine bucket without affecting turbine bucket shape.

4. A method according to claim 1, wherein step (b) is practiced by tuning torsional and stripe mode frequencies without affecting flexure mode frequencies of the turbine bucket.

6. A method of tuning turbine bucket natural frequency comprising:

(a) placing a crystal seed along a desired orientation including all angles between 0°-90° relative to an engine axial direction; and

(b) investment casting the turbine bucket with a single crystal alloy, wherein the desired orientation is selected to tune torsional frequencies without affecting flexure

frequencies and to effect a desired percentage change in the turbine bucket natural frequency.

7. A method according to claim 6, comprising tuning the natural frequency of the turbine bucket without affecting turbine bucket weight.

8. A method according to claim 6, comprising tuning the natural frequency of the turbine bucket without affecting turbine bucket shape.